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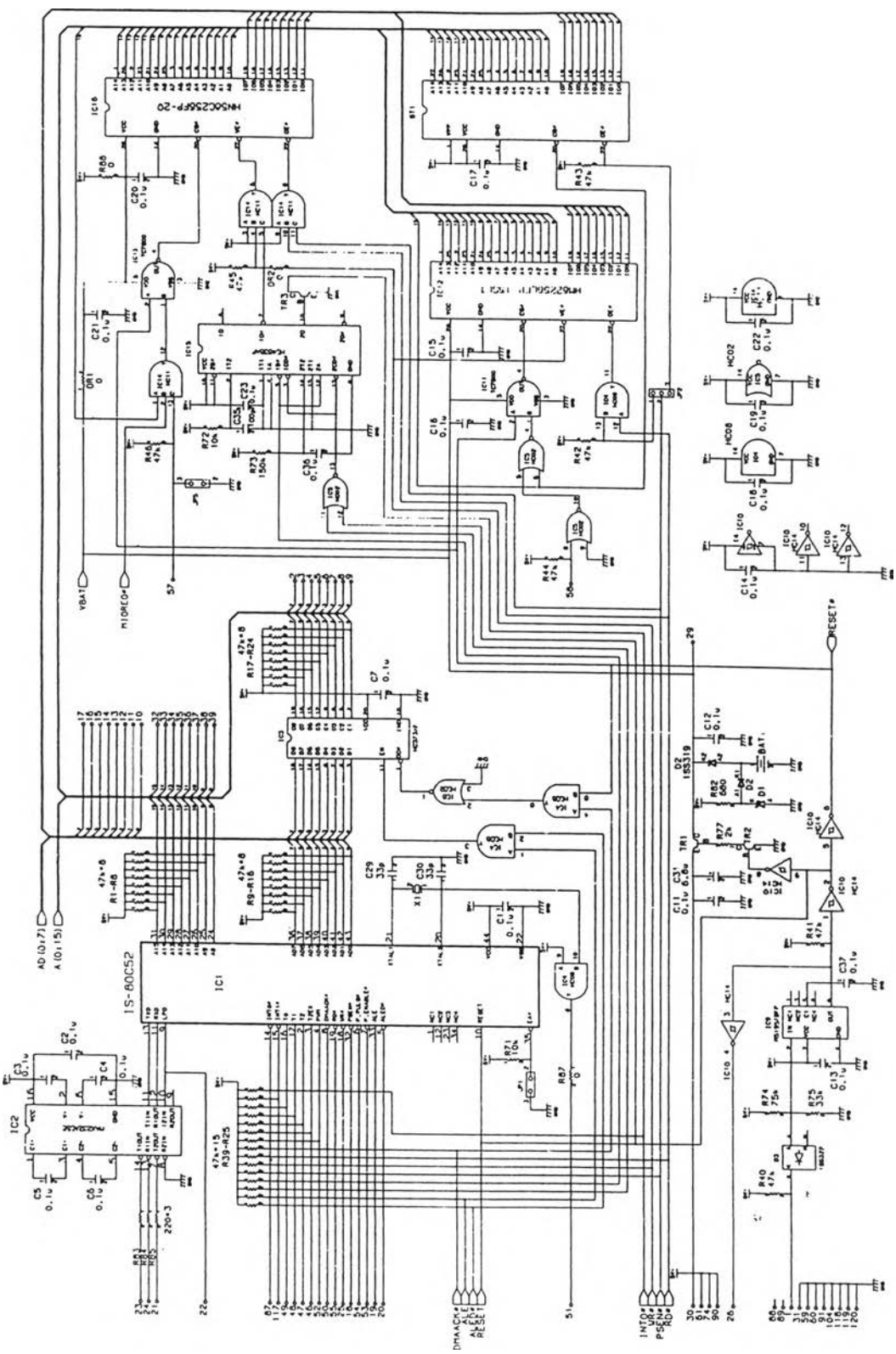
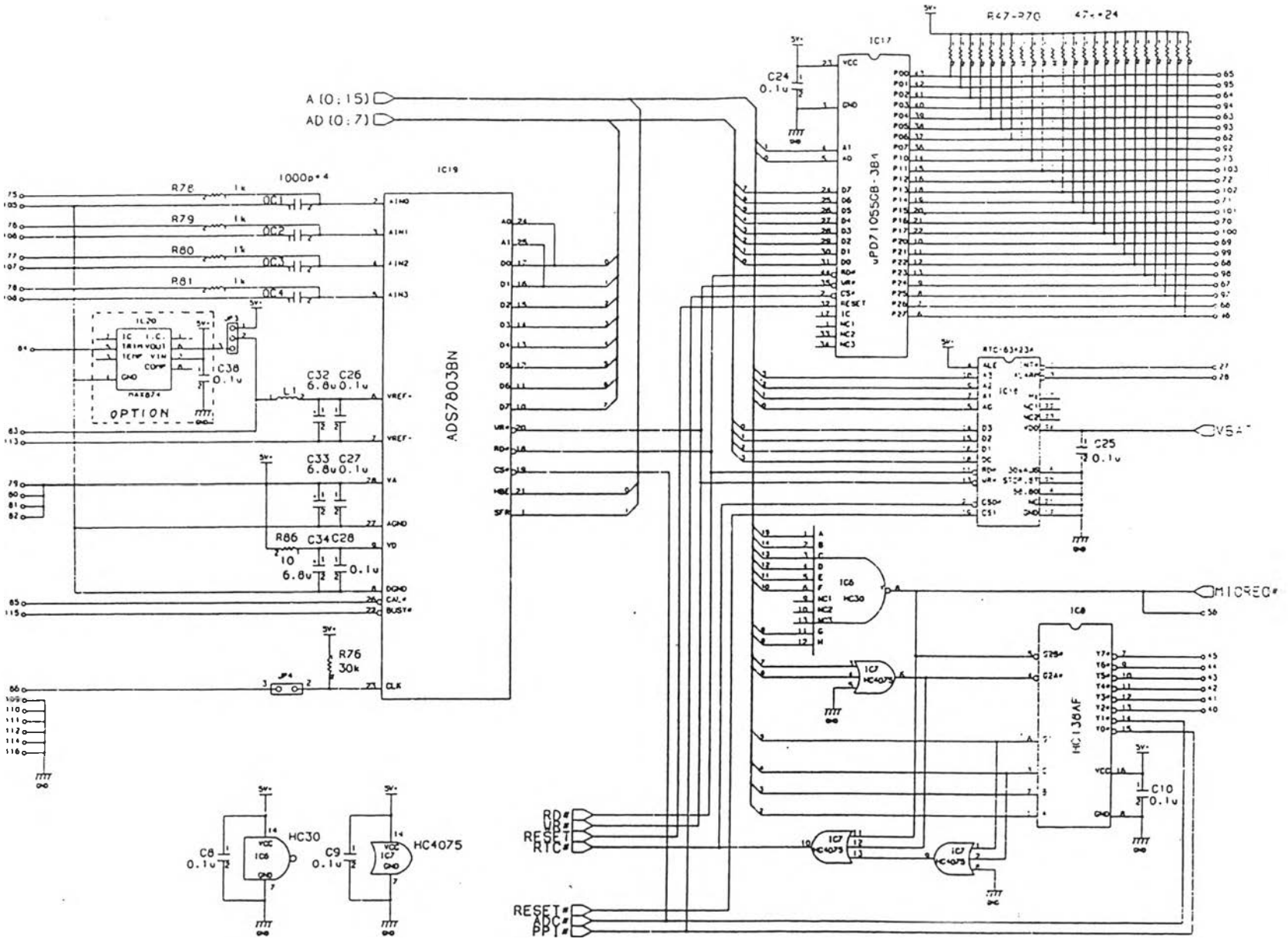
ภาคผนวก

ภาคผนวก ก.




A (0:15)
AD (0:7)
ADS7803BN
IC19
IC17
μPD71055CB-3B1
OPTION
HC30
HC4075
HC138AF
RD#
LB#
RESET
RTC#
RESET
ADC#
PPI#
MICREC#
VSA

ภาคผนวก ช.1

โปรแกรมควบคุมการทำงานของไมโครคอนโทรลเลอร์

```
10    BAUD 9600
20    SCON=052H
30    A=SBUF
40    PA=0FF20H
50    PB=0FF21H
60    PC=0FF22H
70    CP=0FF23H
80    B=XBY(PC)
90    IF A=13H THEN  390   ELSE 30
100   IF B=02H THEN  110   ELSE 80
110   XBY(CP)=81H
120    XBY(PA)=03FH
130   GOSUB  1890
140   GOSUB  1915
150   XBY(PA)=0B8H
160   GOSUB   1890
170   GOSUB   1915
180   XBY(PA)=040H
190   GOSUB   1890
200   GOSUB   1915
210   XBY(PA)=0C0H
220   GOSUB   1890
230   GOSUB   1915
240   PAGE=0B8H
250   FOR I=1 TO 8
260   FOR J=1 TO 64
270   XBY(PA)=0
280   GOSUB  1935
290   GOSUB  1955
300   next j
310   PAGE=PAGE+1
320   XBY(PA)=PAGE
330   GOSUB   1890
340   GOSUB   1915
350   XBY(PA)=040H
360   GOSUB   1890
370   GOSUB   1915
380   next i
390   ccd=2000H
400   L0=0FF28H
410   U0=0FF29H
420   LLD=01h
430   ULD=02h
440   FOR U=1 TO 256
450   XBY(L0)=LLD
460   XBY(U0)=ULD
470   LLD=LLD+1
480   ULD=ULD+1
490   xby(0ff24h)=0
500   AAD=XBY(0FF24H)
510     SBUF=ADD
520   VD=AAD-0.8
530   V=VD/9
540   XBY(ccd)=V
550   ccd=ccd+1
560   FOR I=1 TO 100 :NEXT I
570   NEXT U
580   ccd=2000H
590   TPAGE=40H
600   APAGE=40H
```

```
610   CPAGE=00
620   FOR K=1 TO 256
630   A=XBY(CCD)
640   CCD=CCD+2
700   IF A=00H THEN 705 ELSE 720
705   X=0BFH
710   W=080H
715   GOTO 1780
720   IF A=01H THEN 725 ELSE 740
725   X=0BFH
730   W=080H
735   GOTO 1780
740   IF A=02H THEN 745 ELSE 760
745   X=0BFH
750   W=040H
755   GOTO 1780
760   IF A=03H THEN 765 ELSE 780
765   X=0BFH
770   W=020H
775   GOTO 1780
780   IF A=04H THEN 785 ELSE 800
785   X=0BFH
790   W=010H
795   GOTO 1780
800   IF A=05H THEN 805 ELSE 820
805   X=0BFH
810   W=008H
815   GOTO 1780
820   IF A=06H THEN 825 ELSE 840
825   X=0BFH
830   W=004H
835   GOTO 1780
840   IF A=07H THEN 845 ELSE 860
845   X=0BFH
850   W=002H
855   GOTO 1780
860   IF A=08H THEN 865 ELSE 880
865    X=0BFH
870    W=001H
875   GOTO 1780
880    IF A=09H THEN 885 ELSE 905
885    X=0BEH
890    W=080H
900    GOTO 1780
905    IF A=0AH THEN 910 ELSE 925
910    X=0BEH
915    W=040H
920    GOTO 1780
925    IF A=0BH THEN 930 ELSE 945
930    X=0BEH
935    W=020H
940    GOTO 1780
945    IF A=0CH THEN 950 ELSE 965
950    X=0BEH
955    W=010H
960    GOTO 1780
965    IF A=0DH THEN 970 ELSE 985
970    X=0BEH
975    W=008H
980    GOTO 1780
```

```
985   IF A=0EH THEN 990 ELSE 1010
990   X=0BEH
1000   W=004H
1005   GOTO 1780
1010  IF A=0FH THEN 1015 ELSE 1030
1015   X=0BEH
1020    W=002H
1025   GOTO 1780
1030  IF A=10H THEN 1035 ELSE 1050
1035  X=0BEH
1040  W=001H
1045  GOTO 1780
1050  IF A=11H THEN 1055 ELSE 1070
1055  X=0BDH
1060  W=080H
1065  GOTO 1780
1070  IF A=12H THEN 1075 ELSE 1090
1075  X=0BDH
1080  W=040H
1085  GOTO 1780
1090  IF A=13H THEN 1095 ELSE 1110
1095  X=0BDH
1100  W=020H
1105   GOTO 1780
1110   IF A=14H THEN 1115 ELSE 1130
1115  X=0BDH
1120  W=010H
1125  GOTO 1780
1130  IF A=15H THEN 1135 ELSE 1150
1135  X=0BDH
1140  W=08H
1145  GOTO 1780
1150  IF A=16H THEN 1155 ELSE 1170
1155  X=0BDH
1160  W=04H
1165  GOTO 1780
1170  IF A=16H THEN 1175 ELSE 1190
1175  X=0BDH
1180  W=02H
1185  GOTO 1780
1190  IF A=18H THEN 1195 ELSE 1205
1195  X=0BDH
1200  W=01H
1205  GOTO 1780
1210  IF A=19H THEN 1215 ELSE 1230
1215   X=0BCH
1220   W=080H
1225   GOTO 1780
1230  IF A=1AH THEN 1235 ELSE 1250
1235  X=0BCH
1240  W=040H
1245  GOTO 1780
1250  IF A=1BH THEN 1255 ELSE 1270
1255   X=0BCH
1260   W=020H
1265   GOTO 1780
1270   IF A=1CH THEN 1275 ELSE 1290
1275   X=0BCH
1280   W=010H
1285   GOTO 1780
```

```
1290    IF A=1DH THEN 1295 ELSE 1310
1295    X=0BCH
1300    W=08H
1305    GOTO 1780
1310    IF A=1EH THEN 1315 ELSE 1330
1315    X=0BCH
1320    W=04H
1325    GOTO 1780
1330    IF A=1FH THEN 1340 ELSE 1355
1340    X=0BCH
1345    W=02H
1350    GOTO 1780
1355    IF A=20H THEN 1360 ELSE 1375
1360    X=0BCH
1365    W=01H
1370    GOTO 1780
1375    IF A=21H THEN 1380 ELSE 1395
1380    X=0BBH
1385    W=080H
1390    GOTO 1780
1395    IF A=22H THEN 1400 ELSE 1415
1400    X=0BBH
1405    W=040H
1410    GOTO 1780
1415    IF A=23H THEN 1420 ELSE 1435
1420    X=0BBH
1425    W=020H
1430    GOTO 1780
1435    IF A=24H THEN 1440 ELSE 1455
1440    X=0BBH
1445    W=010H
1450    GOTO 1780
1455    IF A=25H THEN 1460 ELSE 1475
1460    X=0BBH
1465    W=08H
1470    GOTO 1780
1475    IF A=26H THEN 1480 ELSE 1495
1480    X=0BBH
1485    W=04H
1490    GOTO 1780
1495    IF A=27H THEN 1500 ELSE 1515
1500    X=0BBH
1505    W=02H
1510    GOTO 1780
1515    IF A=28H THEN 1520 ELSE 1535
1520    X=0BBH
1525    W=01H
1530    GOTO 1780
1535    IF A=29H THEN 1540 ELSE 1555
1540    X=0BAH
1545    W=80H
1550    GOTO 1780
1555    IF A=2AH THEN 1560 ELSE 1575
1560    X=0BAH
1565    W=40H
1570    GOTO 1780
1575    IF A=2BH THEN 1580 ELSE 1600
1580    X=0BAH
1585    W=20H
1590    GOTO 1780
```

```
1600    IF A=2CH THEN 1605 ELSE 1620
1605   X=0BAH
1610   W=10H
1615   GOTO 1780
1620  IF A=2DH THEN 1625 ELSE 1640
1625  X=0BAH
1630   W=08H
1635   GOTO 1780
1640   IF A=2EH THEN 1645 ELSE 1660
1645   X=0BAH
1650    W=04H
1655    GOTO 1780
1660    IF A=2FH THEN 1665 ELSE  1680
1665    X=0BAH
1670    W=02H
1675    GOTO 1780
1680   IF A=30H THEN 1685 ELSE  1705
1685    X=0BAH
1690    w=01h
1700    GOTO 1780
1705    IF A=31H THEN 1710 ELSE 1725
1710    X=0B9H
1715    W=80H
1720   GOTO 1780
1725   IF A=32H THEN 1726 ELSE 1732
1726   X=0B9H
1728   W=40H
1730   GOTO 1780
1732   IF A=33H THEN 1734 ELSE 1740
1734    X=0B9H
1736    W=20H
1738    GOTO 1780
1740    IF A=34H THEN 1742 ELSE 1748
1742   X=0R9H
1744   W=10H
1746   GOTO 1780
1748   IF A=35H THEN 1750 ELSE 1756
1750   X=0B9H
1752   W=08H
1754   GOTO 1780
1756   IF A=36H THEN 1758 ELSE 1764
1758   X=0B9H
1760    W=04H
1762    GOTO 1780
1764    IF A=37H THEN 1766 ELSE  1772
1766    X=0B9H
1768    W=02H
1770    GOTO 1780
1772   IF A=38H THEN 1774 ELSE 1178
1774    X=0B9H
1775    w=01h
1776    GOTO 1780
1777    X=0B9H
1778    W=00H
1779    GOTO 1780
1780    IF CPAGE<63 THEN 1785  ELSE 1830
1785    XBY(PA)=X
1790    GOSUB 1890
1795    TPAGE=TPAGE+1
1800    XBY(PA)=TPAGE
```

```
1805    GOSUB 1890
1810     XBY(PA)=W
1815    GOSUB 1935
1820     CPAGE=CPAGE+1
1825      NEXT k
1830     xby(pa)=X
1835     GOSUB 1915
1840     APAGE=APAGE+1
1845     xby(pa)=APAGE
1850      GOSUB 1915
1855      xby(pa)=W
1860      GOSUB 1955
1865      CPAGE=80H
1870      NEXT K
1875     STOP
1880    ccd=2000h
1885    a=xby(ccd)
1890   XBY(PB)=19H
1900   XBY(PB)=18H
1905   XBY(PB)=19H
1910   RETURN
1915   XBY(PB)=29H
1920   XBY(PB)=28H
1925   XBY(PB)=29H
1930   RETURN
1935   XBY(PB)=1BH
1940   XBY(PB)=1AH
1945   XBY(PB)=1BH
1950   RETURN
1955   XBY(PB)=2BH
1960   XBY(PB)=2AH
1965   XBY(PB)=2BH
1970   RETURN
```

ภาคผนวก ข.2

โปรแกรมควบคุมการทำงานของไมโครคอมพิวเตอร์

```
Program XY_SCAN;
Uses crt,Graph;

Const
  Pattern : FillPatternType = ($FF,$FF,$FF,$FF,$FF,$FF,$FF,$FF);
  Setport = $2f8;(*com2*)
  Null = chr($00);
 Var
  Max   :integer;
  MaxX  :integer;
  MaxY  :integer;
  Count :integer;
  Loop  :integer;
  WhereX :integer;
  WhereY :integer;
  Free   :integer;
  StepY  :array[0..257] of integer; {304}
  Channal:integer;
  Ch     :char;
  strloop:string{4};
  Logo   :string{33};

Procedure Beep;
Begin
 Write(chr(7));
End;

Procedure Boom;
 Begin
  for count:=500 to 3000 do
   Begin
    Sound(count);
     Delay(1);
     End;
     Nosound;
     End;

 Procedure Tick;
 Begin
   count:=1500;
   while count<=2500 do
    Begin
    sound(count);
    delay(1);
    count:=count+100
    End;
    Nosound;
    End;

 Procedure  Tock;
 Begin
 count:=500;
 While count<=1500 do
 Begin
 sound(count);
 delay(1);
 count:=count+100;
 End;
 nosound;
 End;
```

```
Procedure GraphInit;
Var Gr,GM:Integer;
Begin
 Gr:=Detect;
 InitGraph(Gr,Gm,'c:\tp\bgi');
 MaxX:=GetMaxX;
 MaxY:=GetMaxY;
End;

procedure SetGrp(X1,Y1,X2,Y2,color:integer);
Begin
 SetFillPattern(Pattern,Color);
 Bar((X1*2)+15,380-Y1,(X2*2)+15,380-Y2);
End;

Procedure Setline(X1,Y1,X2,Y2,Color:integer);
Begin
 Setcolor(Color);
 Line((X1*2)+15,380-Y1,(X2*2)+15,380-Y2);
End;

Procedure SetBar(X1,Y1,X2,Y2,Color:integer);
Begin
 SetFillPattern(Pattern,Color);
 Bar(X1,Y1,X2,Y2);
End;

Procedure SetScalc(Color:integer);
Begin
 SetColor(Color);
 Line((MaxX+1)div 8*7,15,(MaxX+1)div 8*7,MaxY-61);{}
 Line((MaxX+1)div 8*6,15,(MaxX+1)div 8*6,MaxY-61);{}
 Line((MaxX+1)div 8*5,15,(MaxX+1)div 8*5,MaxY-61);{}
 Line((MaxX+1)div 8*4,15,(MaxX+1)div 8*4,MaxY-61);{Set Line X}
 Line((MaxX+1)div 8*3,15,(MaxX+1)div 8*3,MaxY-61);{}
 Line((MaxX+1)div 8*2,15,(MaxX+1)div 8*2,MaxY-61);{}
 Line((MaxX+1)div 8,15,(MaxX+1)div 8,MaxY-61);{}
 Line(15,381-50,MaxX-15,381);  {}
 Line(15,381-50,MaxX-15,381-50); {}
 Line(15,381-100,MaxX-15,381-100); {}
 Line(15,381-150,MaxX-15,381-150); {Set Line Y}
 Line(15,381-200,MaxX-15,381-200); {}
 Line(15,381-250,MaxX-15,381-250); {}
 Line(15,381-300,MaxX-15,381-300); {}
 Line(15,381-350,MaxX-15,381-350); {}
End;

Procedure SetBarControl(Color:integer);
Begin
 SetBar(2,MaxY-2,MaxX-2,MaxY-59,white);
 SetBar(12,Maxy-59,MaxX-12,MaxY-57,White);
 SetBar(2,Maxy-59,4,MaxY-2,White);
 SetBar(2,Maxy-2,MaxX-2,MaxY-4,DarkGray);
 SetBar(MaxX-2,Maxy-59,MaxX-5,MaxY-2,DarkGray);
 SetBar(4,4,MaxX-4,MaxY-60,LightGray);
 SetBar(2,2,MaxX-2,4,White);
 SetBar(2,2,4,MaxY-60,White);
```

```
 SetBar(2,MaxY-4,MaxX-2,MaxY-2,DarkGray);
 SetBar(MaxX-1,2,MaxX-5,MaxY-60,DarkGray);
 SetBar(MaxX-3,2,MaxX-5,2,White);{ }
 SetBar(MaxX-4,3,MaxX-5,3,White);{Conner Up Out}
 SetBar(MaxX-5,4,MaxX-5,4,White);{ }
 SetBar(12,12,MaxX-12,14,DarkGray);
 SetBar(12,12,14,MaxY-58,DarkGray);{ }
 SetBar(13,MaxY-58,14,MaxY-58,White);{Conner In Down}
 SetBar(14,MaxY-59,14,MaxY-59,White);{ }
 SetBar(MaxX-12,12,MaxX-14,MaxY-60,White);
 SetBar(MaxX-14,12,MaxX-12,12,DarkGray);{ }
 SetBar(MaxX-14,13,MaxX-13,13,DarkGray);{Conner In Up}
 SetBar(MaxX-14,14,MaxX-14,14,DarkGray);{ }
 SetBar(15,15,MaxX-15,MaxY-61,green);
 Setcolor(black);
 Line(10,MaxY-54,MaxX-10,MaxY-54);
 Line(10,MaxY-7,MaxX-10,Maxy-7);
 Line(10,MaxY-7,10,MaxY-54);
 Line(MaxX-10,MaxY-7,MaxX-10,MaxY-54);

End;

Procedure setSpeed;
Begin
 Setbar(MaxX-150 MaxY-30,MaxX-50,MaxY-10,Darkgray);
 Setbar(MaxX-135,MaxY-30,MaxX-65,MaxY-10,Black);
 Setcolor(Blue);
 Outtextxy(MaxX-125,MaxY-40,'Channel');
 Setcolor(LightGreen);
 Outtextxy(MaxX-145,MaxY-25,'-');
 Outtextxy(MaxX-110,MAXY-25,'+');
 (*Outtextxy(MaxX-110,MaxY-25,'0500');*)
End;

Procedure SetX_YRecorder;
Var i:integer;
Begin
 SetBar(0,0,GetMaxX,GetMaxY,Blue);
 SetBarControl(LightGray);
 SetSpeed;
 Setcolor(Blue);
 Outtextxy(MaxX div 12*5,MaxY-50,'X-Y Recorder');
 Setcolor(Magenta);
 Outtextxy(15,MaxY-35,'*Reset');
 Outtextxy(15,MaxY-20,'+Start');
 Outtextxy(15,MaxY-50,'/Range');
 WhereX:=MaxX div 16*5;
 WhereY:=MaxY-20;
 Logo:='Department of Nuclear Technology';
 For count:=1 to 33 do
  Begin
   Setcolor(Black);
   Outtextxy(whereX+count*8,whereY,logo[count]);
  End;
End;

Procedure Screen_end;
Var Str1:string[27];
 str2:string[33];
 str3:string[23];
```

```
 str4:string[25];
Begin

 Textbackground(black);
 Clrscr;
 loop:=2;
 str1:='By.Mr Suthipong Chumkhutod';
 str2:='Department of Nuclear Technology';
 str3:='Faculty of Engineering';
 str4:='Chulalongkorn University';
 Gotoxy(15,6);
 for count:=1 to 32 do
 begin
  if loop>15 then loop:=2;
  textcolor(loop);
  write(str1[count]);
  loop:=loop+1;
 end;
 Gotoxy(25,7);
 for count:=1 to 33 do
 begin
  if loop>15 then loop:=2;
  textcolor(loop);
  write(str2[count]);
  loop:=loop+1;
 end;
 Gotoxy(15,9);
 for count:=1 to 23 do
 begin
  if loop>15 then loop:=2;
  textcolor(loop);
  write(str3[count]);
  loop:=loop+1;
 end;
 for count:=1 to 25 do
 begin
  if loop>15 then loop:=2;
  textcolor(loop);
  write(str4[count]);
  loop:=loop+1;
 end;
 Gotoxy(17,25);
End;

procedure RunX_YRecorder;
var InOK, ScaleOK:boolean;
  Init  :integer;
  st    :string;
Begin
  GraphInit;
  SetX_Yrecorder;

  Channal:=0;
  loop:=500;
  InOK:=True;
  ScaleOK:=False;
  ch:=readkey:
  case ch of
  '+': Begin
       repeat
```

```
    Channal:=channal+1;
    Port[$2fc]:=$03;
    Port[setport]:=$13;
    Port[$2fe]:=$0b0;
    StepY[channal]:=port[setport];
    SetLine(channal-1,stepY[channal-1],channal,stepY[channal],red);
    Setbar(MaxX-135,MaxY-30,MaxX-65,MaxY-10,Black);
    str(channal:3,st);
    outtextxy(MaxX-125,MaxY-25,(st));
    delay(500);
    until channal=256;
    Setcolor(Red);
    Outtextxy(maxX div 12*5,MaxY-30,'Completel');
    repeat until keypressed;
    closegraph;
    End;
  '*':begin
    closegraph;
    port[setport]:=$12;
    end;
  end(*end case*);
  Screen_end;
End;

Begin
   RunX_Yrecorder;
   End.
```

```
610   CPAGE=00
620   FOR K=1 TO 256
630   A=XBY(CCD)
640   CCD=CCD+2
700   IF A=00H THEN 705 ELSE 720
705   X=0BFH
710   W=080H
715   GOTO 1780
720   IF A=01H THEN 725 ELSE 740
725   X=0BFH
730   W=080H
735   GOTO 1780
740   IF A=02H THEN 745 ELSE 760
745   X=0BFH
750   W=040H
755   GOTO 1780
760   IF A=03H THEN 765 ELSE 780
765   X=0BFH
770   W=020H
775   GOTO 1780
780   IF A=04H THEN 785 ELSE 800
785   X=0BFH
790   W=010H
795   GOTO 1780
800   IF A=05H THEN 805 ELSE 820
805   X=0BFH
810   W=008H
815   GOTO 1780
820   IF A=06H THEN 825 ELSE 840
825   X=0BFH
830   W=004H
835   GOTO 1780
840   IF A=07H THEN 845 ELSE 860
845   X=0BFH
850   W=002H
855   GOTO 1780
860   IF A=08H THEN 865 ELSE 880
865    X=0BFH
870    W=001H
875   GOTO 1780
880    IF A=09H THEN 885 ELSE 905
885    X=0BEH
890    W=080H
900    GOTO 1780
905    IF A=0AH THEN 910 ELSE 925
910    X=0BEH
915    W=040H
920    GOTO 1780
925    IF A=0BH THEN 930 ELSE 945
930    X=0BEH
935    W=020H
940    GOTO 1780
945    IF A=0CH THEN 950 ELSE 965
950    X=0BEH
955    W=010H
960    GOTO 1780
965    IF A=0DH THEN 970 ELSE 985
970    X=0BEH
975    W=008H
980    GOTO 1780
```

ภาคผนวก ค.

19-2446; Rev 0; 8/91

MAXIM

Quad Comparator with Programmable Threshold

General Description

The MAX516 combines four low-power, programmable-threshold comparators on a single CMOS IC. Separate 8-bit digital-to-analog converters (DACs) drive the comparator inverting (-) inputs so that individual trip thresholds can be digitally set. All noninverting (+) comparator inputs are brought out as analog inputs (AIN0-AIN3). Each comparator output swings high when its analog input exceeds its digitally set threshold. All four DACs share a common reference input to optimize matching and eliminate external trims.

Digital inputs and comparator outputs are compatible with TTL and CMOS logic. A separate logic supply (V_{CC}) allows comparator output levels to be set independently of V_{DD}. The MAX516 operates conveniently from a single supply with V_{DD} tied to V_{CC}. Commercial, extended, and military temperature ranges are provided in 24-pin narrow DIP and wide SO packages.

Applications

Window Comparators

Power-Supply Monitors

Alarm Limit Detectors

Battery Chargers

Automated Test Equipment

Process Control

Features

- ♦ 4 Comparators and 4 DACs
- ♦ Digitally Set Threshold
- ♦ Monotonic Over Temperature
- ♦ Parallel Microprocessor Interface
- ♦ +5V to +15V Supply Operation

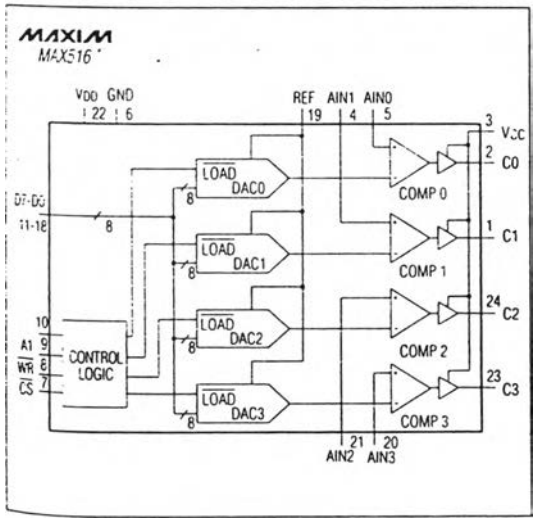
Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE	ERROR (LSBs)
MAX516ACNG	0°C to +70°C	24 Narrow Plastic DIP	±1
MAX516BCNG	0°C to +70°C	24 Narrow Plastic DIP	±2
MAX516ACWG	0°C to +70°C	24 Wide SO	±1
MAX516BCWG	0°C to +70°C	24 Wide SO	±2
MAX516BC/D	0°C to +70°C	Dice*	±2
MAX516AENG	-40°C to +85°C	24 Narrow Plastic DIP	±1
MAX516BENG	-40°C to +85°C	24 Narrow Plastic DIP	±2
MAX516AEWG	-40°C to +85°C	24 Wide SO	±1
MAX516BEWG	-40°C to +85°C	24 Wide SO	±2
MAX516AMRG	-55°C to +125°C	24 Narrow CERDIP**	±1
MAX516BMRG	-55°C to +125°C	24 Narrow CERDIP**	±2

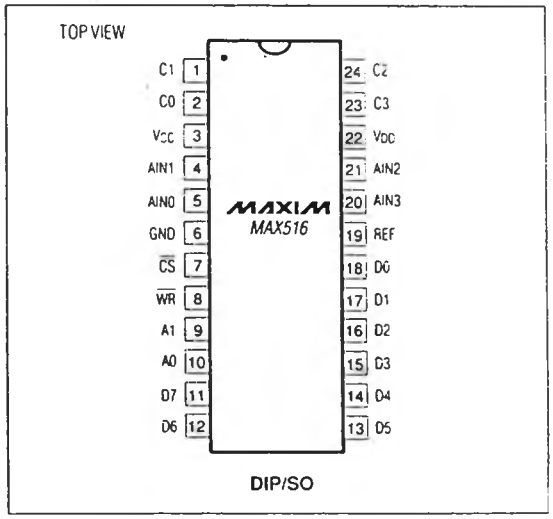
** Contact factory for dice specifications.*

*** Contact factory for availability and processing to MIL-STD-883.*

Functional Diagram



Pin Configuration



Quad Comparator with Programmable Threshold

ABSOLUTE MAXIMUM RATINGS

V_{DD} to GND . . . . . -0.3V, +17V
V_{CC} to GND . . . . . -0.3V, V_{DD} + 0.3V
V_{DD} to V_{CC} . . . . . -0.3V, +17V
Digital Input Voltage to GND . . . . . -0.3V, V_{DD} + 0.3V
REF to GND . . . . . -0.3V, V_{DD} + 0.3V
Comparator Input to GND . . . . . -0.3V, V_{DD} + 0.3V
C0–C3 to GND (Note 1) . . . . . GND, V_{CC} + 0.3V
Continuous Power Dissipation (T_A = +70°C)
Narrow Plastic DIP (derate 8.7mW/°C above +70°C) 480mW
Wide SO (derate 11.8mW/°C above +70°C) 650mW
Narrow CERDIP (derate 12.5mW/°C above +70°C) . 690mW

Operating Temperature Ranges
MAX516_ C__ . . 0°C to +70°C
MAX516_ E__ -40°C to +85°C
MAX516_ MRG -55°C to +125°C
Storage Temperature Range -65°C to +165°C
Lead Temperature (soldering 10 sec) . +300°C

Note 1: The outputs may be shorted to GND or V_{DD}, provided the package's power dissipation is not exceeded

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability

ELECTRICAL CHARACTERISTICS

(V_{DD} = V_{CC} = +4.75V, REF = +1.25V or V_{DD} = V_{CC} = +16.5V, REF = +10V; GND = 0V; T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
STATIC PERFORMANCE							
Resolution	N			8			Bits
Total Unadjusted Error	TUE	MAX516A				±1	LSB
		MAX516B				±2	
Relative Accuracy	INL	MAX516A				±0.5	LSB
		MAX516B				±1	
Differential Nonlinearity	DNL	Guaranteed monotonic				±1	LSB
Full-Scale Error		MAX516A				±0.5	LSB
		MAX516B				±1	
Full-Scale Temperature Coefficient		V_{DD} = 15V, REF = 10V			±5		ppm/°C
Zero-Code Error		T_A = +25°C	MAX516A			±5	mV
		T_A = T_{MIN} to T_{MAX}	MAX516A			±10	
		T_A = +25°C	MAX516B			±10	
		T_A = T_{MIN} to T_{MAX}	MAX516B			±15	
Zero-Code Temperature Coefficient					±3		µV/°C
REFERENCE INPUT (4.75V ≤ V_{DD} ≤ 16.5V)							
Reference Input Range	REF			1.25		V_{DD} -3.50	V
Reference Input Resistance	RREF	Worst-case code		3.0	4.5		kΩ
Reference Input Capacitance	CREF	Worst-case code (Note 2)			100	250	pF
COMPARATOR INPUT (4.75V ≤ V_{DD} ≤ 16.5V)							
Comparator Input Range	V_{AIN}			0		V_{DD}	V
Comparator Input Bias Current	I_B	T_A = +25°C			50	300	nA
		T_A = T_{MIN} to T_{MAX}			100	400	

Quad Comparator with Programmable Threshold

ELECTRICAL CHARACTERISTICS (continued)

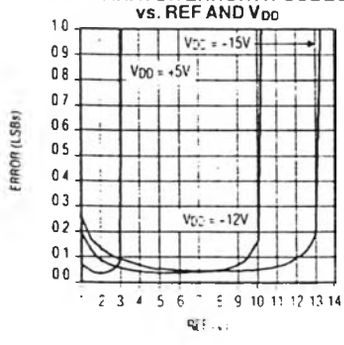
(V_{DD} = V_{CC} = +4.75V, REF = +1.25V or V_{DD} = V_{CC} = +16.5V, REF = +10V; GND = 0V; T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DIGITAL INPUTS D0-D7, $\overline{WR}$, $\overline{CS}$, (4.75V ≤ V_{DD} ≤ 16.5V)						
Input High Voltage	V_{INH}		2.4			V
Input Low Voltage	V_{INL}				0.8	V
Input Leakage Current	I_{IN}	V_{IN} = 0V or V_{DD}			±1	µA
Input Capacitance	C_{IN}	(Note 2)			10	pF
DIGITAL OUTPUTS C0–C3 (V_{CC} = 5V)						
Output High Voltage	V_{OH}	I_{SOURCE} = 200µA	V_{CC}-1			V
Output Low Voltage	V_{OL}	I_{SINK} = 1.6mA			0.4	V
DYNAMIC PERFORMANCE (1.25V ≤ REF ≤ V_{DD} -3.5V, 0V ≤ AIN < V_{DD} -2V)						
Digital Input to Comparator Out Delay	t_{DCO}	(Note 3)		0.6	2.0	µs
Analog Input to Comparator Out Delay	t_{ACO}	(Note 4)		0.6	1.5	µs
TIMING CHARACTERISTICS						
$\overline{CS}$ to $\overline{WR}$ Setup Time	t_{CS}		0			ns
$\overline{CS}$ to $\overline{WR}$ Hold Time	t_{CH}		0			ns
Address to $\overline{WR}$ Setup Time	t_{AS}		50	30		ns
Address to $\overline{WR}$ Hold Time	t_{AH}		5	0		ns
Data Valid to $\overline{WR}$ Setup Time	t_{DS}		50	30		ns
Data Valid after $\overline{WR}$ Hold Time	t_{DH}		5	0		ns
$\overline{WRITE}$ Pulse Width	t_{WR}		120	50		ns
POWER SUPPLIES						
V_{DD} Range	V_{DD}		4.75		16.5	V
V_{CC} Range	V_{CC}		4.75		V_{DD}+0.30	V
Positive Supply Current	I_{DD}	Logic inputs < V_{IL} or > V_{IH}			10	mA
Logic Supply	I_{CC}				10	µA

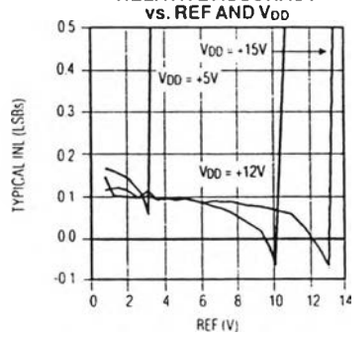
Note 2: Guaranteed by design. Not production tested.
Note 3: V_{DD} = 5.00V, differential comparator input voltage changes by 1.25V with 5mV overdrive. V_{IN} must be 3.5V less than V_{DD} or longer propagation delays will result.
Note 4: Not tested, but guaranteed by correlation to t_{DCO}.

Typical Operating Characteristics

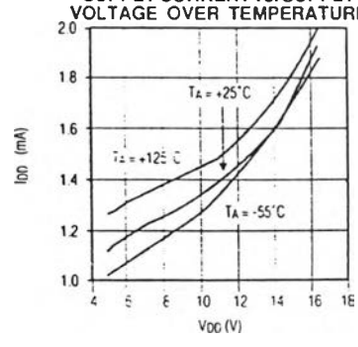
COMPARATOR ERROR AT CODE 255 vs. REF AND V_{DD}



RELATIVE ACCURACY vs. REF AND V_{DD}



SUPPLY CURRENT vs. SUPPLY VOLTAGE OVER TEMPERATURE



Quad Comparator with Programmable Threshold

Pin Description

PIN	NAME	FUNCTION
1, 2	C1, C0	Comparator Outputs
3	VCC	Comparator Output Supply
4, 5	AIN1, AIN0	Comparator Analog Inputs
6	GND	Ground
7	CS	$\overline{\text{CHIP SELECT}}$
8	WR	$\overline{\text{WRITE}}$
9, 10	A1, A0	DAC Address Inputs
11-18	D7-D0	DAC Data Inputs, 8 bits
19	REF	Reference Input
20, 21	AIN3, AIN2	Comparator Analog Inputs
22	VDD	Positive Supply Voltage
23, 24	C3, C2	Comparator Outputs

Detailed Description

The MAX516 contains four analog comparators and four matched 8-bit digital-to-analog converters (DACs). The voltage output of each DAC is expressed in the equation:

$$V_{DAC} = REF \times N/256,$$

where N is the numerical equivalent of the 8-bit DAC input code (D0-D7). N ranges from 0 to 255 and may be set to a different level for each DAC (Table 1). The DAC output, V_{DAC}, does not appear on an output pin of the MAX516 but is instead compared to an analog input signal by one of four internal comparators (see *Functional Diagram*). A comparator output is high when AIN is more positive than the comparator's digitally set threshold.

Table 1. Comparator Threshold vs. DAC Input Code

DAC CODE MSB	DAC CODE LSB	COMPARATOR THRESHOLD
1111	1111	$+REF\left(\frac{255}{256}\right)$
1000	0001	$+REF\left(\frac{129}{256}\right)$
1000	0000	$+REF\left(\frac{128}{256}\right) = +\frac{REF}{2}$
0111	1111	$+REF\left(\frac{127}{256}\right)$
0000	0001	$+REF\left(\frac{1}{256}\right)$
0000	0000	0V

NOTE: $1LSB = (REF)(2^{-8}) = +REF\left(\frac{1}{256}\right)$

Reference Input

Comparator trip thresholds vary digitally between 0V and 1LSB below REF. All DACs share the same reference input.

The input impedance of REF is code dependent. The lowest impedance, typically 2kΩ, occurs when 0101 0101 (HEX 55) is loaded into D0-D7 on all four DACs. When 0000 0000 is loaded into all DACs, REF appears as an open circuit. Because the input resistance at REF is code dependent, the reference source should have an output impedance of no more than 4Ω to maintain linearity. Input capacitance at REF is also code dependent and typically varies between 100pF and 250pF.

Comparator Inputs

The "+" input of each comparator is brought out to AIN0-AIN3. Comparator input bias current is typically 100nA. Analog source resistances below 1.25kΩ generate less than 250µV of bias-current induced comparator offset error.

Digital Interface

The digital inputs (D0-D7, $\overline{CS}$, $\overline{WR}$) are both TTL and 5V CMOS logic compatible; however, the power-supply current, I_{DD}, depends on input logic levels. Supply currents will be highest with TTL levels (tested limits are with worst-case logic levels). Supply current is reduced when digital inputs are driven near GND and above 4V.

Address lines A0 and A1 select which DAC receives data from the input port. Because $\overline{CS}$ and $\overline{WR}$ are internally ORed, the write cycle begins only after both go low, but data is latched and transferred to a DAC when either input returns high. Figure 1 shows the input control logic, Table 2 lists DAC addresses, and Table 3 is the truth table for $\overline{WR}$ and $\overline{CS}$. Figure 2 shows write-cyle timing.

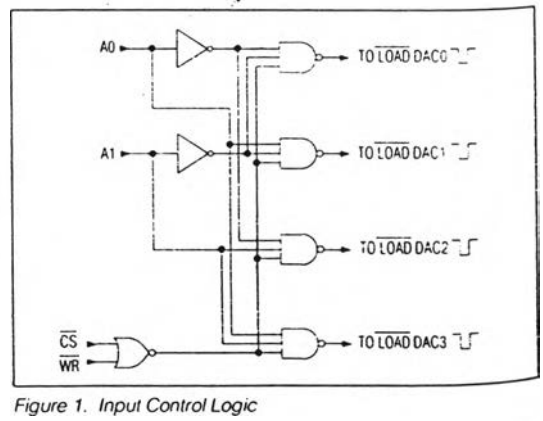


Figure 1. Input Control Logic

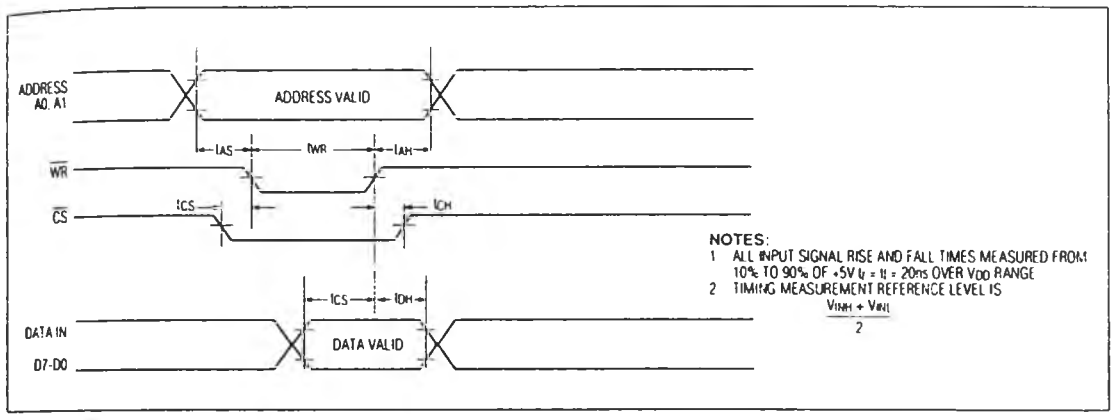


Figure 2. Write-Cycle Timing

Table 2. DAC Addressing

A1	A0	SELECTED DAC
0	0	DAC0 Input Register
0	1	DAC1 Input Register
1	0	DAC2 Input Register
1	1	DAC3 Input Register

Table 3. Write-Cycle Truth Table

$\overline{CS}$	$\overline{WR}$	FUNCTION
1	X	No operation. The MAX516 is deselected. Existing register contents remain unchanged
0	0	DAC contents for selected address are loaded, but do not update the DAC until $\overline{WR}$ goes high.
0	↑	Latch D0-D7 into input register of the selected DAC on rising edge.

NOTES: X = Don't Care, ↑= Rising Edge

Applications Information

Power-Supply and Reference Operating Ranges

The MAX516 is fully specified to operate with V_{DD} between +4.75V and +16.5V and is specified to operate with a reference input range of +1.25V to V_{DD} -3.5V.

The comparator output supply, V_{CC}, has a range of +4.5V to (V_{DD} + 0.3V). This allows the comparators' logic-high output levels to be set independently from V_{DD}. In most applications, simply connect V_{CC} and V_{DD} together. Comparator outputs typically swing within 200mV of the supply rails when loaded with CMOS logic inputs.

Hysteresis

When analog input signals are slow moving or contain noise, comparator outputs may "chatter" near the threshold point. Be sure that proper power-supply bypass capacitors are in place (see *Grounds and Bypassing* section), because supply current rises when an output switches.

Hysteresis may be added to any or all comparators to further resist oscillation during output transitions. This is accomplished with two resistors, as shown in Figure 3. When hysteresis is added, the threshold point will shift slightly as a result of the voltage divider formed by R1 and R2. The amount of shift is described below:

$$V_{TH} = V_T\left(\frac{R1}{R2} + 1\right)$$

$$V_{TL} = V_T\left(\frac{R1}{R2} + 1\right) - V_{CC}\left(\frac{R1}{R2}\right)$$

$$V_{HYST} = V_{TH} - V_{TL}$$

$$V_{HYST} = V_{CC}\left(\frac{R1}{R2}\right)$$

V_T is the threshold voltage set by the internal DAC with no hysteresis connected. V_{TH} is the shifted high-going threshold with hysteresis added. V_{TL} is the shifted low-going threshold with hysteresis. V_{HYST} is the total hysteresis and equals V_{TH} - V_{TL}. Note that V_{TL} and V_{HYST} change with V_{CC}. With V_{CC} = 5V, R1 = 1kΩ, and R2 = 200kΩ, V_{HYST} = 25mV. Even though R1 is relatively small, the impedance seen by the signal source is large: R1 + R2. However, if R1 is large, input bias current (400nA

Quad Comparator with Programmable Threshold

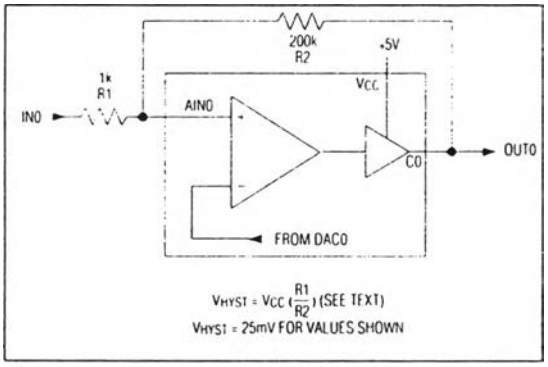


Figure 3. Adding Hysteresis to Any Comparator

max over temp.) may add offset error. 1kΩ x 400nA = 0.4mV offset error is due to bias current.

Grounds and Bypassing

Careful PC-board layout significantly minimizes crosstalk among the reference input, comparator outputs, and digital inputs. Keep digital and analog lines separate, and use ground traces as shields between them where possible. Separate AIN0-AIN3 and REF from each other by running a ground trace between these pins.

Bypass both V_{DD} and V_{CC} to GND with a combination of a 0.1µF low ESR and a 4.7µF capacitor close to the device. If V_{DD} and V_{CC} are connected together, only one set of bypass capacitors is needed. If REF is not an AC input, it should be bypassed as well. Keep bypass-capacitor leads short for best supply noise rejection.

Applications

Threshold detection is often useful in automated test applications. Four individual thresholds can be independently altered under software control.

Figure 4 shows the connection for a hardware window comparison. DAC0 provides the upper trip point, DAC1 the lower trip point. The difference between the trip points is the window size. The AIN0 and AIN1 inputs are tied together. One logic output is inverted and then ORed with the noninverted comparator output. The window output goes high when the analog input sits between the thresholds set by DAC0 and DAC1. The external logic in Figure 4 can also be simulated in software, or use a single comparator to perform a window comparison by loading two threshold limits in succession and noting the comparator results of each (Figure 5).

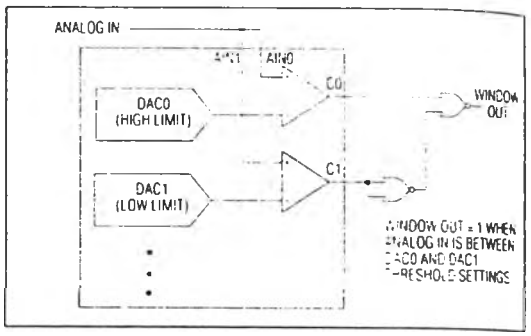


Figure 4. Window Comparison

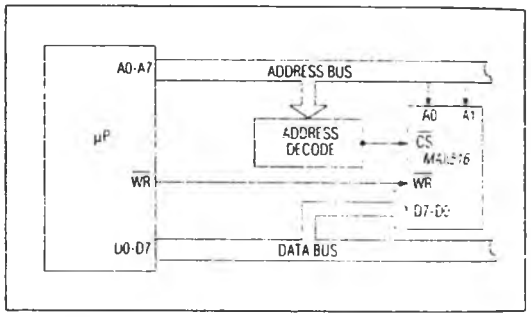
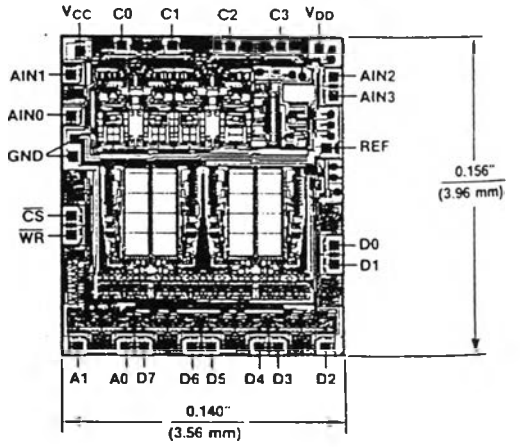


Figure 5. Microprocessor Interface

Chip Topography



NOTE: Substrate connected to V_{DD}

19-4323; Rev 3; 7/92

MAXIM

+5V-Powered Multi-Channel RS-232 Drivers/Receivers

General Description

The MAX220-MAX249 family of line drivers/receivers is intended for all EIA-232E and V.28/V.24 communications interfaces, and in particular, for those applications where ±12V is not available.

These parts are particulary useful in battery-powered systems since their low-power shutdown mode reduces power dissipation to less than 5µW. The MAX233, MAX235 and MAX245-MAX247 use no external components and are recommended for applications where printed circuit board space is critical.

All members of the family except the MAX231 and MAX239 need only a single +5V supply for operation. The RS-232 drivers/receivers have on-board charge-pump voltage converters which convert the +5V input power to the ±10V needed to generate the RS-232 output levels. The MAX231 and MAX239, designed to operate from +5V and +12V, contain a +12V to -12V charge-pump voltage converter.

Since nearly all RS-232 applications need both line drivers and receivers, the family includes both receivers and drivers in one package. The wide variety of RS-232 applications require differing numbers of drivers and receivers. Maxim offers a wide selection of RS-232 driver/receiver combinations in order to minimize the package count (see *Selection Guide*).

Applications

Portable Computers

Low-Power Modems

Interface Translation

Battery-Powered RS-232 Systems

Multi-Drop RS-232 Networks

Features

Superior to Bipolar

- **Operate from Single +5V Power Supply (+5V and +12V – MAX231 and MAX239)**
- **Low-Power Receive Mode in Shutdown (MAX223/MAX242)**
- **Meet All EIA-232E and V.28 Specifications**
- **Multiple Drivers and Receivers**
- **3-State Driver and Receiver Outputs**
- **Open-Line Detection (MAX243)**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX220CPE	0°C to +70°C	16 Plastic DIP
MAX220CSE	0°C to +70°C	16 Narrow SO
MAX220CWE	0°C to +70°C	16 Wide SO
MAX220C/D	0°C to +70°C	Dice*
MAX220EPE	-40°C to +85°C	16 Plastic DIP
MAX220ESE	-40°C to +85°C	16 Narrow SO
MAX220EWE	-40°C to +85°C	16 Wide SO
MAX220MJE	-55°C to +125°C	16 CERDIP
MAX222CPN	0°C to +70°C	18 Plastic DIP
MAX222CWN	0°C to +70°C	18 Wide SO
MAX222C/D	0°C to +70°C	Dice*
MAX222EPN	-40°C to +85°C	18 Plastic DIP
MAX222EWN	-40°C to +85°C	18 Wide SO
MAX222EJN	-40°C to +85°C	18 CERDIP
MAX222MJN	-55°C to +125°C	18 CERDIP

Ordering Information continued on last page.

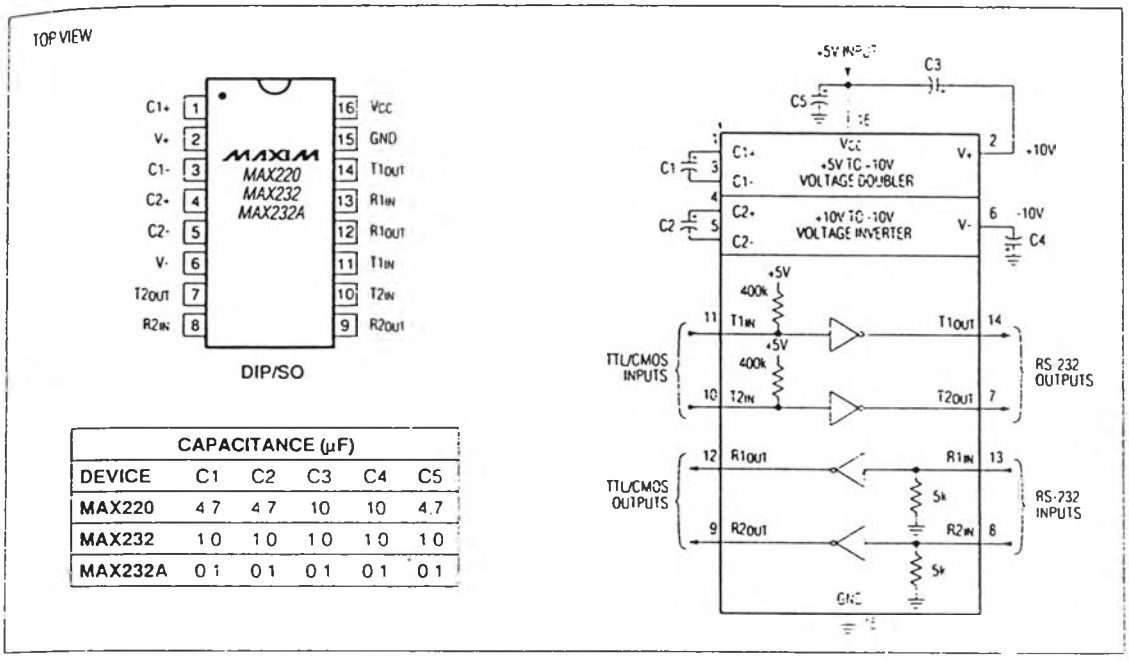
* *Contact factory for dice specifications.*

+5V-Powered Multi-Channel RS-232 Drivers/Receivers

Interface Products

Part Number	Power Supply (V)	# of RS-232 Drivers	# of RS-232 Receivers	# of Ext. Caps	Nominal Cap. Value (µF)	Shutdown & 3-State	Supply Current (mA max)	Guaranteed Data Rate (kbits/sec max)	Features
MAX220	+5	2	2	4	4.7/10	No	2	20	Ultra low-power, industry-standard pinout
MAX222	+5	2	2	4	0.1	Yes	10	116	MAX232A with shutdown
MAX223	+5	4	5	4	1.0	Yes	15	20	+5V IBM PC serial port w/ receivers active in shutdown
MAX230 (MAX200)	+5	5	0	4	1.0	Yes	15 (20)	20	5 drivers with shutdown
MAX231	+5 and +7.5 to +13.2	2	2	2	1.0	No	1/5	20	Standard +5/+12V or battery supplies; same functions as MAX232
MAX232 (MAX202)	+5	2	2	4	1.0	No	10 (15)	20	Industry standard
MAX232A	+5	2	2	4	0.1	No	10	116	Higher slew rate, small caps
MAX233 (MAX203)	+5	2	2	0	-	No	10 (15)	20	No external caps
MAX233A	+5	2	2	0	-	No	10	116	No external caps, high slew rate
MAX234 (MAX204)	+5	4	0	4	1.0 (0.1)	No	15 (20)	20	Replaces 1488
MAX235 (MAX205)	+5	5	5	0	-	Yes	15 (20)	20	No external caps
MAX236 (MAX206)	+5	4	3	4	1.0 (0.1)	Yes	15 (20)	20	Shutdown, three-state
MAX237 (MAX207)	+5	5	3	4	1.0 (0.1)	No	15 (20)	20	Complements IBM PC serial port
MAX238 (MAX208)	+5	4	4	4	1.0 (0.1)	No	15 (20)	20	Replaces 1488 and 1489
MAX239 (MAX209)	+5 and +7.5 to +13.2	3	5	2	1.0 (0.1)	No	1/15 (20)	20	Standard +5/+12V or battery supplies; single package solution for IBM PC serial port
MAX240	+5	5	5	4	1.0	Yes	15	20	DIP or flatpak package
MAX241 (MAX211)	+5	4	5	4	1.0 (0.1)	Yes	15 (20)	20	Complete IBM PC serial port
MAX242	+5	2	2	4	0.1	Yes	10	116	Separate shutdown and enable
MAX243	+5	2	2	4	0.1	No	10	116	Open-line detection simplifies cabling
MAX244	+5	8	10	4	1.0	No	25	64	High slew rate
MAX245	+5	8	10	0	-	Yes	25	64	High slew rate, int. caps, two shutdown modes
MAX246	+5	8	10	0	-	Yes	25	64	High slew rate, int. caps, three shutdown modes
MAX247	+5	8	9	0	-	Yes	25	64	High slew rate, int. caps, nine operating modes
MAX248	+5	8	8	4	1.0	Yes	25	64	High slew rate, selective half-chip enables
MAX249	+5	6	10	4	1.0	Yes	25	64	MAX248 with 2 complete IBM PC serial ports
MAX560	+3	4	5	4	1.0	Yes	8	20	+3V MAX561 + receivers active in shutdown
MAX561	+3	4	5	4	1.0	Yes	8	20	+3V Complete IBM PC serial port
RS-232 ISOLATION PRODUCTS									
MAX250	+5	2	2	-		Yes	-	20	Isolated RS-232 chipset
MAX251	+5	2	2	-		Yes	-	20	Isolated RS-232 chipset
MAX252A	+5	2	2	0		Yes	90	9.6	UL recognized, 1500V isolation
MAX252B	+5	2	2	0		Yes	90	9.6	Economical 500V isolation

+5V-Powered Multi-Channel RS-232 Drivers/Receivers



CAPACITANCE (µF)					
DEVICE	C1	C2	C3	C4	C5
MAX220	4.7	4.7	10	10	4.7
MAX232	1.0	1.0	1.0	1.0	1.0
MAX232A	0.1	0.1	0.1	0.1	0.1

Figure 5. MAX220/232/232A Pin Configuration and Typical Operating Circuit

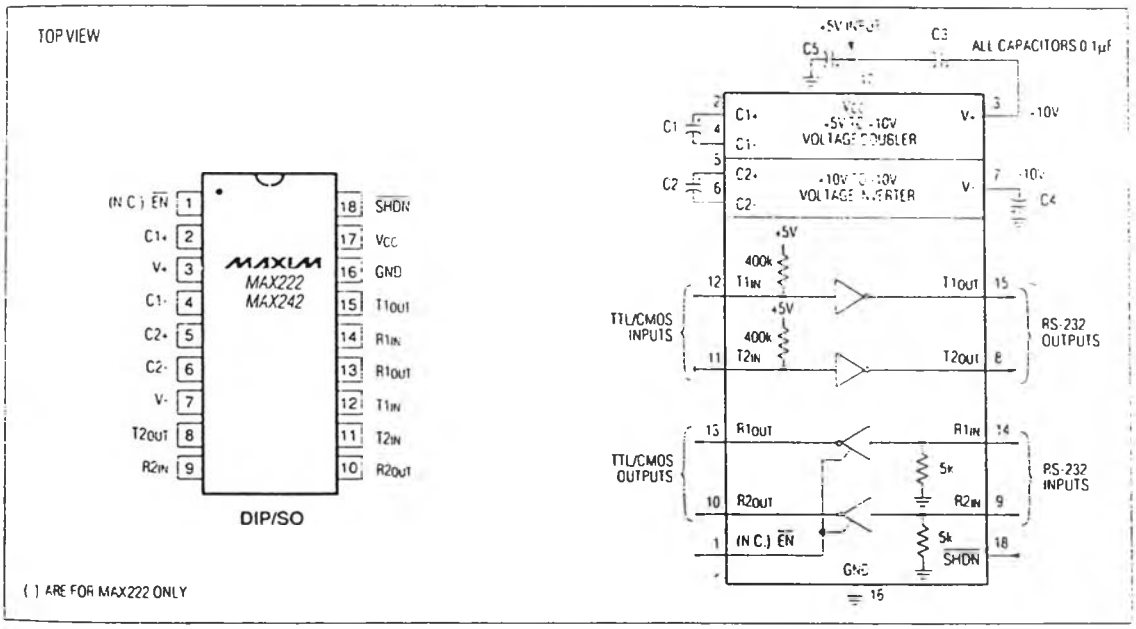


Figure 6. MAX222/MAX242 Pin Configuration and Typical Operating Circuit

+5V-Powered Multi-Channel RS-232 Drivers/Receivers

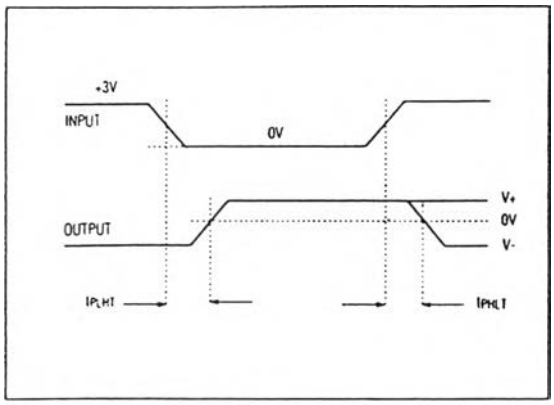


Figure 1. Transmitter Propagation Delay Timing

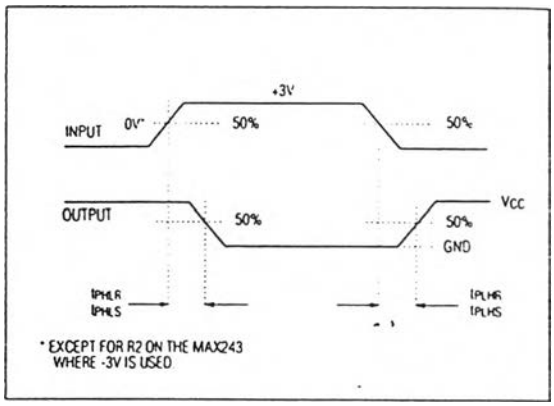


Figure 2. Receiver Propagation Delay Timing

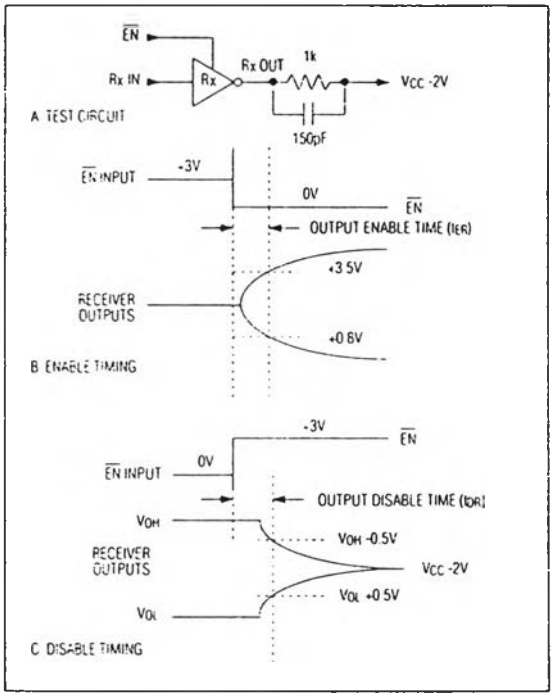


Figure 3. Receiver-Output Enable and Disable Timing

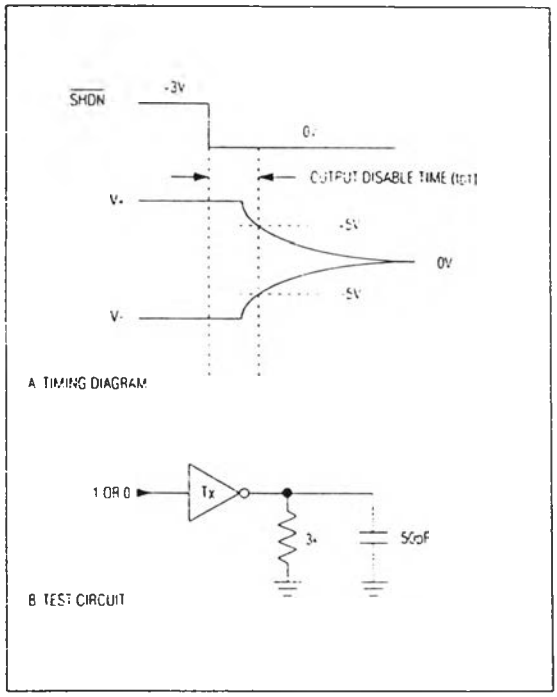


Figure 4. Transmitter-Output Disable Timing

+5V-Powered Multi-Channel RS-232 Drivers/Receivers

ELECTRICAL CHARACTERISTICS – MAX244-MAX249 (continued)

(V_{CC} = +5V ±10%, external capacitors C1-C4 = 1µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
POWER SUPPLY AND CONTROL LOGIC						
Operating Supply Voltage			4.5		5.5	V
V_{CC} Supply Current (Normal Operation)	No load			11	30	mA
	3kΩ loads on all outputs			57		
Shutdown Supply Current	T_A = +25°C			8	25	µA
	T_A = T_{MIN} to T_{MAX}				50	
Control Input	Leakage Current				±1	µA
	Threshold Low			1.4	0.8	V
	Threshold High		2.4	1.4		
AC CHARACTERISTICS						
Transition Slew Rate	C_L = 50pF to 2500pF, R_L = 3kΩ to 7kΩ, V_{CC} = 5V, T_A = +25°C, measured from +3V to -3V or -3V to +3V		5	10	30	V/µs
Transmitter Propagation Delay TTL to RS-232 (Normal Operation), Figure 1	t_{PHLT}			1.3	3.5	µs
	t_{PLHT}			1.5	3.5	
Receiver Propagation Delay RS-232 to TTL (Normal Operation), Figure 2	t_{PHLR}			0.6	1.5	µs
	t_{PLHR}			0.6	1.5	
Receiver Propagation Delay RS-232 to TTL (Low Power Mode), Figure 2	t_{PHLS}			0.6	10	µs
	t_{PLHS}			3.0	10	
Transmitter + to - Propagation Delay Difference (Normal Operation)	t_{PHLT} - t_{PLHT}			350		ns
Receiver + to - Propagation Delay Difference (Normal Operation)	t_{PHLT} - t_{PLHT}			350		ns
Receiver-Output Enable Time, Figure 3	t_{ER}			100	500	ns
Receiver-Output Disable Time, Figure 3	t_{DR}			100	500	ns
Transmitter Enable Time, Figure 4	t_{ET}	MAX246-249 (excludes charge-pump startup)		5		µs
		MAX245, MAX247 (includes charge-pump startup)		10		ms
Transmitter Disable Time, Figure 3	t_{DT}			100		ns

Note 5: The 300Ω minimum specification complies with EIA-232E, but the actual resistance when in shutdown mode or V_{CC} = 0 is 10MΩ as is implied by the leakage specification.

+5V-Powered Multi-Channel RS-232 Drivers/Receivers

ABSOLUTE MAXIMUM RATINGS – MAX244-MAX249

Supply Voltage (V_{CC}) ..... -0.3V to +6V
Input Voltages
T_{IN}, ENA, ENB, ENR, ENT, ENRA, ENRB, ENTA, ENTB ..... -0.3V to (V_{CC} + 0.3V)
R_{IN} ..... ±25V
T_{OUT} (Note 4) ..... ±15V
R_{OUT} ..... -0.3V to (V_{CC} + 0.3V)
Short Circuit (1 output at a time)
T_{OUT} to GND ..... Continuous
R_{OUT} to GND ..... Continuous

Continuous Power Dissipation (T_A = +70°C)
40-Pin Plastic DIP (derate 11.11mW/°C above +70°C) .. 611mW
44-Pin PLCC (derate 13.33mW/°C above +70°C) 1067mW
Operating Temperature Ranges:
MAX24_C_ _ ..... 0°C to +70°C
MAX24_E_ _ ..... -40°C to +85°C
Storage Temperature Range ..... -65°C to +160°C
Lead Temperature (soldering, 10 sec) ..... +300°C

Note 4: Input voltage measured with transmitter output in a high-impedance state, shutdown, or V_{CC} = 0V.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS – MAX244-MAX249

(V_{CC} = +5.0V ±10%, external capacitors C1-C4 = 1µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
RS-232 TRANSMITTERS						
Input Logic Threshold Low				1.4	0.8	V
Input Logic Threshold High			2	1.4		V
Logic Pull-Up/Input Current	Tables 1A-1C	Normal operation		10	50	µA
		Shutdown		±0.01	±1	
Data Rate	Tables 1A-1C, normal operation				64	kbits/sec
Output Voltage Swing	All transmitter outputs loaded with 3kΩ to GND		±5	±7.5		V
Output Leakage Current (Shutdown)	Tables 1A-1C			±0.01	+25	µA
				±0.01	±25	
Transmitter Output Resistance	V_{CC} = V_+ = V_- = 0V, V_{OUT} = ±2V (Note 5)		300	10M		Ω
Output Short-Circuit Current	V_{OUT} = 0V		±7	±30		mA
RS-232 RECEIVERS						
RS-232 Input Voltage Operating Range					±25	V
RS-232 Input Threshold Low	V_{CC} = 5V		0.8	1.3		V
RS-232 Input Threshold High	V_{CC} = 5V			1.8	2.4	V
RS-232 Input Hysteresis	V_{CC} = 5V		0.2	0.5	1.0	V
RS-232 Input Resistance			3	5	7	kΩ
TTL/CMOS Output Voltage Low	I_{OUT} = 3.2mA			0.2	0.4	V
TTL/CMOS Output Voltage High	I_{OUT} = -1.0mA		3.5	V_{CC}-0.2		V
TTL/CMOS Output Short-Circuit Current	Sourcing V_{OUT} = GND		-2	-10		mA
	Sinking V_{OUT} = V_{CC}		10	30		
TTL/CMOS Output Leakage Current	Normal operation, outputs disabled. Tables 1A-1C, 0V ≤ V_{OUT} ≤ V_{CC}			±0.05	±10	µA

8052AH-BASIC

ADVANCE INFORMATION

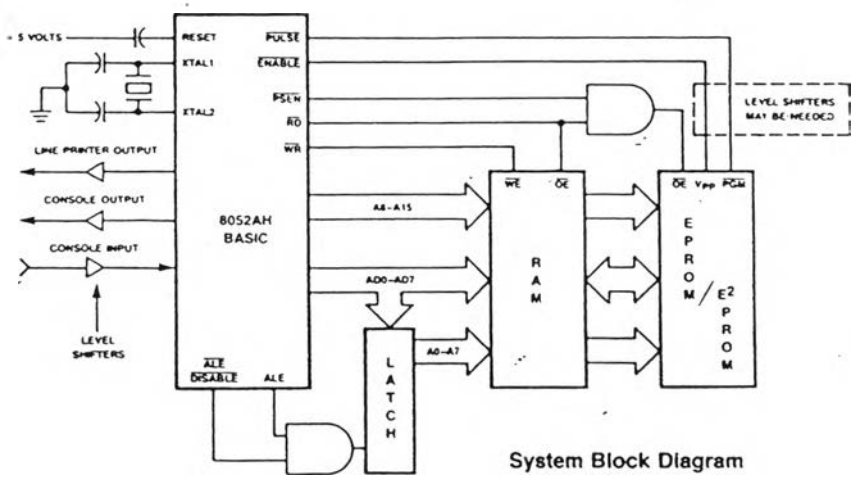
- Full BASIC Interpreter in ROM on a Single Chip
- BCD Floating Point Math
- Generates All Timing Necessary to Program EPROMS and E²PROMS
- Fast Tokenized Interpreter
- "Stand Alone" Software Development
- All Arithmetic and Utility Routines Can Be Called From Assembly Language
- Interrupts Can Be Handled By BASIC or Assembly Language
- Built-In Accurate REAL TIME CLOCK
- Multiple User Programs
- Programs May Reside In RAM, EPROM or E²PROM
- Built In Radix Conversion — Hex to Decimal and Decimal to Hex

8052AH-BASIC is an 8052AH microcontroller with a complete full-featured BASIC interpreter, MCS* BASIC-52, resident in the 8K of available ROM. This Software-On-Silicon product is specifically designed to address the needs of process control, measurement, and instrumentation applications. MCS BASIC-52 allows 8052AH users to write programs in the popular BASIC language, which is much simpler to write and easier to understand than assembly language.

In addition to the standard BASIC commands and functions, such as floating point arithmetic and transcendental operations, MCS BASIC-52 contains many unique features that allow the user to perform tasks that usually require assembly language. Bit-wise logical operators, such as AND, OR, and EXCLUSIVE-OR are supported as well as hexadecimal arithmetic.

A minimum amount of hardware is required to support MCS BASIC-52. Small systems can be constructed with only a latch, 1K bytes of external memory, and the appropriate serial port drivers. With the addition of a transistor, a gate, and a couple of passive components, MCS BASIC-52 can program EPROM or E²PROM devices with the users application program. Both the standard and the int$_e$ligent Programming™ algorithms are supported.

MCS BASIC-52 is an interpreted language. This allows the user to develop a program interactively without the cumbersome and repetitive process of editing, assembling, loading, and running which is required by assemblers and compilers. MCS BASIC-52 was designed to permit the programmer to develop resident high level language software using the high performance 8052AH device.



System Block Diagram

ABSOLUTE MAXIMUM RATINGS*

Ambient Temperature Under Bias . . . 0°C to 70°C

Storage Temperature . . . . . −65°C to +150°C

Voltage on Any Pin With Respect to Ground (V_{SS}) . . . . −0.5V to +7V

Power Dissipation . . . . . 2 Watts

NOTICE: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

DC CHARACTERISTICS (T_A = 0°C to 70°C, V_{CC} = 4.5V to 5.5V, V_{SS} = 0V)

Symbol	Parameter	Min	Max	Unit	Test Conditions
VIL	Input Low Voltage	−0.5	0.8	V	
VIH	Input High Voltage (Except RST and XTAL2)	2.0	V_{CC} + 0.5	V	
VIH1	Input High Voltage to RST for Reset, XTAL2	2.5	V_{CC} + 0.5	V	XTAL1 to V_{SS}
VOL	Output Low Voltage Port 1, A8–15, Control Functions		0.45	V	IOL = 1.6mA
VOL1	Output Low Voltage ALE, PSEN (Note 1)		0.45	V	IOL = 3.2mA
VOH	Output High Voltage Port 1, A8–15, Control Functions	2.4		V	IOH = −80μA
VOH1	Output High Voltage AD0–7, ALE, $\overline{PSEN}$	2.4		V	IOH = −400μA
IIL	Logical 0 Input Current Port 1, A8–15 Control Functions		−800	μA	Vin = 0.45V
IIL2	Logical 0 Input Current XTAL2		−2.5	mA	XTAL1 at V_{SS}, Vin = 0.45V
IL1	Input Leakage Current To AD0–7 EA		±10	μA	0.45V<Vin<V_{CC}
IIH1	Input High Current to RST/VPD For Reset		500	μA	Vin = V_{CC} − 1.5V
ICC	Power Supply Current		175	mA	All outputs disconnected
CIO	Capacitance of I/O Buffer		10	pF	f_C = 1MHz, T_A = 25°C

See page 6 for Notes

Commands	Statements	Operators
RUN	BAUD	ADD (+)
LIST	CALL	DIVIDE (/)
LIST#	CLEAR	EXPONENTIATION (**)
NEW	CLEARS	MULTIPLY (*)
NULL	CLEARI	SUBTRACT (-)
RAM	CLOCK0	LOGICAL AND (.AND.)
ROM	CLOCK1	LOGICAL OR (.OR.)
XFER	DATA	LOGICAL X-OR (.XOR.)
PROG	READ	LOGICAL NOT
PROG1	RESTORE	ABS ( )
PROG2	DIM	INT ( )
FPROG	DO-WHILE	SGN ( )
FPROG1	DO-UNTIL	SQR ( )
FPROG2	END	RND
	FOR-TO-STEP	LOG ( )
	NEXT	EXP ( )
	GOSUB	SIN ( )
	RETURN	COS ( )
	GOTO	TAN ( )
	ON-GOTO	ATN ( )
	ON-GOSUB	=, >, >=, <, <=, <>
	IF-THEN-ELSE	ASC ( )
	INPUT	CHR ( )
	LET	CBY ( )
	ONERR	DBY ( )
	ONEXT1	XBY ( )
	ONTIME	GET
	PRINT	IE
	PRINT#	IP
	PH0.	PORT1
	PH0 #	PCON
	PH1	RCAP2
	PH1.#	T2CON
	PUSH	TCON
	POP	TMOD
	PWM	TIME
	REM	TIMER0
	RET1	TIMER1
	STOP	TIMER2
	STRING	TIME
	UI0	XTAL
	UI1	MTOP
	UO0	LEN
	UO1	FREE
		PI

Figure 1. MCS® BASIC-52 Software Feature Set

PORT 1

A general purpose quasi-bidirectional 8-bit input/output port. The individual pins on PORT 1 all have alternate functions which may or may not be implemented by the user. The alternate functions are as follows:

PORT 1.0 (T2)

Can be used as the trigger input to TIMER/COUNTER 2. A one (1) must be written to this port pin output latch in order for this function to operate. Details of the T2 trigger function are covered in the Microcontrollers Handbook. Order Number 210918-002.

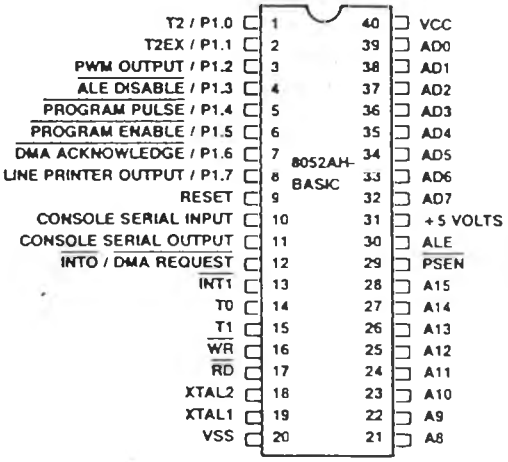


Figure 2. Configuration

PORT 1.1 (T2EX)

Can be used as the external input to TIMER/COUNTER 2. A one (1) must be written to this port pin output latch in order for this function to operate. Details of the T2 trigger function are covered in the Microcontroller Users Manual.

PORT 1.2 (PWM OUTPUT)

This pin is used as the PWM output port when the PWM statement is executed. PWM stands for Pulse Width Modulation and is used to generate pulses of varying duty cycle and frequency.

PORT 1.3 ($\overline{\text{ALE DISABLE}}$)

This pin is used to disable the ALE signal to the external address latch when the EPROM/E^{2}PROM programming feature is used. In a system, this pin is logically anded with ALE.

PORT 1.4 ($\overline{\text{PROGRAMMING PULSE}}$)

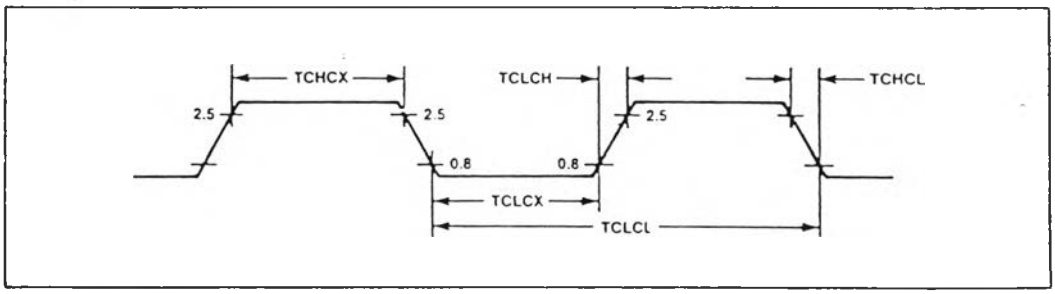
When the EPROM/E^{2}PROM programming feature is used, this pin provides the proper programming pulse width to program EPROM and INTELligent EPROM® devices. MCS BASIC-52 actually calculates the proper programming pulse width from the system crystal value (XTAL) to assure the proper timing of this pulse. When used to program E^{2}PROM devices, the length of this pulse is not critical. This pin is active in the logical zero (0) state.

Note 1: Vol is degraded when the 8032AH/8052AH rapidly discharges external capacitance. This AC noise is most pronounced during emission of address data. When using external memory, locate the latch or buffer as close to the 8032AH/8052AH as possible.

Datum	Emitting Ports	Degraded I/O Lines	VOL (peak) (max)
Address	A8–15, AD0–7	P1, Control Functions	0.8V
Write Data	AD0–7	P1, Control Functions, ALE	0.8v

EXTERNAL CLOCK DRIVE CHARACTERISTICS (XTAL2)

Symbol	Parameter	Variable Clock f = 3.5 MHz to 12 MHz		Unit
		Min	Max	
TCLCL	Oscillator Period	83.3	286	ns
TCHCX	High Time	20		ns
TCLCX	Low Time	20		ns
TCLCH	Rise Time		20	ns
TCHCL	Fall Time		20	ns



ประวัติผู้เขียนวิทยานิพนธ์

นายสุทธิพงษ์ ชุ่มชุนทด เกิดเมื่อวันที่ 14 มกราคม พ.ศ. 2514 ที่จังหวัดกรุงเทพมหานคร สำเร็จการศึกษาปริญญาครุศาสตร์อุตสาหกรรมศาสตร์บัณฑิต สาขาวิศวกรรมไฟฟ้า คณะครุศาสตร์อุตสาหกรรม สถาบันเทคโนโลยีพระจอมเกล้าพระนครเหนือ ในปีการศึกษา 2537 และเข้าศึกษาต่อในหลักสูตรวิศวกรรมศาสตร์มหาบัณฑิต สาขานิวเคลียร์เทคโนโลยี ภาควิชานิวเคลียร์เทคโนโลยี คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย ในปีการศึกษา 2540